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Develop Low-Weight/Low-Cost AC/DC Regulated Converter for V-22 Applications
Failure Detection System for Composite Joints
Selective Depainting and Precision Cleaning
Innovative Protection Coating Systems for Aircraft
Non-Chromated Flexible Primer
Innovative Thermal Barrier Technology for Exterior Aircraft Structures
Design Assistant and Software Tools for Systems Identification and Adaptive Fault-Tolerant Control
Weight Efficient Corrosion Resistant Composite Heat Exchangers
Low Cost Turbojet Engine for Expendable Target Applications
Motion Coupling in a Deployable Virtual Environment Trainer
Alternate Time Management Schemes for Use in High Level Architecture (HLA) Federate Simulation
Client/Server part Task Trainer Interface
Shallow Water Directional Noise Measurement Sensors
High-Bandwidth Scene Projector Drive Electronics
Novel Signal Processing Algorithms to Exploit and Classify Active Sonobuoy Returns
Small GPS Controlled Reception Pattern Antenna for Aircraft
Expendable Broadband Projectors for Undersea Warfare
Compact Mid-Infrared Laser for IRCM
EO/IR Sensor Applications on Supersonic Vehicles
GPS Ground Plane Nulling Antenna
Low-Cost GPS Oscillator
Real-Time Pattern Recognition Algorithms for High Density Commercial and Military Applications
Geometric Patterning of Radar Absorptive and Reflective Materials (RARM) and Selective Combining of RARM materials to Achieve Improved EMI Protection and Significantly Reduced Radar Cross Section

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Priority Number:

TITLE: Develop Low-Weight/Low-Cost AC/DC Regulated Converter for V-22 Applications

OBJECTIVE: Demonstrate the advantages of novel power electronic and thermal designs in cost (less than \$23K), weight (less than 30 lbs.), reliability (2 time increase in mean time between failure(MTBF)) and performance improvements for AC/DC regulated converter applications for V-22 electrical power distribution system.

DESCRIPTION: Three regulated converters (CVs) are installed on the V-22 aircraft. The CVs convert aircraft 115/200 VAC, 360-457 Hz, 3-phase power into a regulated 28.7 +/-0.3 VDC output. The CV also control, protect and monitor the DC system which includes charging the main aircraft battery and configuring the system's seven contactors and one remote controlled circuit breaker. The CVs are rated at 200 amps DC continuous; provide up to 450 amps following a 9 kW power curve for transient overloads and fault clearing conditions; and provide up to 450 amps for auxiliary power unit (APU) starting following a minimum 6 kW power curve (and maximum of 10 KVA input during APU start).

An innovative design will be required to meet the 30-lb maximum weight while achieving the stringent power quality, electromagnetic interference (EMI) and thermal requirements for an aerospace application. The power quality requirements are defined in MIL-STD-704D (30 Sep 80), titled, "Aircraft Electric Power Characteristics." The EMI requirements are defined in MIL-STD-461B (01 Apr 80) and MIL-STD-462. Their respective titles are "Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference" and "Electromagnetic Interference Characteristics, Measurement of." Thermally, the CV should operate its components in safe operating temperatures for a high reliable and long life operation (MTBF 6,000 hrs) at altitudes from sea level to 30,000 feet and at temperature extremes from +71°C maximum to -54°C minimum. The APU start function is required only up to 17,500 feet. Innovative thermal technologies may be considered. However, the aircraft ECS system will provide cooling air. The total pressure drop through the CV should not be greater than 1.0 inches of water when furnished with its minimum air mass flow rate of 7.0 lbs./min at an inlet temperature of 55°C and at an ambient pressure of 14.7 psia. All other operating temperatures and pressures will correspondingly scale the mass flow rate. The CV efficiency should be greater than 70% at 25 amps DC output; 80% from 100 to 300 amps DC output; and 65% at 450 amps DC output. The size of the CV is not to exceed the requirements stated in the Bell Boeing Envelope Drawing 901-375-201.

The procurement cost requirement of less than \$23K is for a production CV that meets all V-22 military qualification requirements including shock, vibration, temperature altitude, environmental and explosive atmosphere. Specific requirements are defined in Bell Boeing Report No. 901-375-738 Revision LTR G.

Phase I: Conduct a feasibility study that defines the design required to meet the objectives for weight, reliability, production cost and electrical performance. This study must include potential commercial applications for this converter. Simulations and/or breadboard testing of electrical and thermal solutions may be used if required for tradeoff purposes. If the goals cannot be met, the feasibility study effort must identify research areas needed to accomplish the goal in Phase II.

Phase II: Develop, test, and operationally demonstrate the regulated CV designed under the Phase I effort. The demonstration shall demonstrate all modes of electrical operation including the CV's ability to control, protect and monitor the DC system. This also includes charging the main aircraft battery and configuring the system's contactors. Output signal loads (i.e., contactor relays and logic status) may be simulated for demonstration purposes. Performance evaluation should also include EMI testing at an accredited laboratory. The EMI tests should be CEO3 and RE02. The unit should be fabricated for demonstration purposes and is not be required to be tested for shock and vibration. The design analysis effort should address all CV military specification requirements, be provided in the engineering analysis and documented in the final report, even though the CV will not be tested to all requirements. The unit should also be thermally tested varying temperature and mass airflow rates to evaluate potential innovative thermal solutions.

Phase III: Produce the hardware developed under Phase II and evaluate in Boeing's system level bench test. Perform qualification development and safety-of-flight qualification testing, then install and flight-test on V-22 aircraft.

COMMERCIAL POTENTIAL: The commercial airlines would benefit from a regulated power supply that has a power density (kW/lb.) 34% higher and costs less than today's V-22 converter.

References: None

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Why are we proposing this topic: The existing V-22 regulated CV utilizes state-of-the-art electric circuit topology and logic components. However, to meet the numerous specification requirements such as EMI, vibration and thermal the CV design is adversely impacted in size, weight, cost and reliability. The power electronic research field has been changing very quickly in the last few years with universities and small businesses leading the way with innovative solutions to our power supply problems. The development risk to achieve the weight, cost, reliability and performance goals of this proposal is high and meets the definition of advanced development as defined in the 29 October, 1998 Memorandum from the Naval Aviation Science & Technology Office (Ser AIR-4.0T1/99-379). A significant cost reduction must result from reducing the engineering development time and complexity of control algorithms and this is the technology area that has been improved upon in the latest literature. Increasing power density while maintaining component junction temperatures at least 25°C below maximum operating temperature for all modes of operation presents problems on meeting reliability requirements. Conventional thermal solutions will not achieve the MTBF goal. It requires a new approach, whether it is a thermal transfer method or more efficient circuit topology and control scheme. The goals of this effort are to achieve:

- A 45% reduction in cost. This is a $75K saving per aircraft. Navy procurement cost would be $30K/unit, which assumes a 30% increase for the Boeing contract.
- A 34% increase in current density. This is a 30 lbs. saving per aircraft.
- A 2X increase in reliability. Increase mean flight hours between design controllable failures from 3,000 to 6,000.

Total Ownership Cost Reduction: Significant savings will be derived from the two times increase in mean flight hours between design controllable failures. This will reduce life-cycle procurement by half and reduce maintenance hours for the electrical system.

Category: Advanced development

Science/Technology Area: Aerospace Propulsion and Power

Navy Requirement: This topic addresses Air Warfare, Platforms (3.2.b): develop technologies to enable next generation vertical flight through reducing weight and complexity; Logistics Support, Maintenance (8.1.d): develop new technologies to enhance equipment maintenance and overhaul with goal of maintenance self-sufficiency among naval forces; and Logistics Support, Maintenance (8.1.e): design increased reliability, maintainability, and availability in equipment.

PRODUCT LINE TEAM AREA: Aircraft

SPONSOR: PMA-275, PMA-299

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Priority Number:

TITLE: Failure Detection System for Composite Joints

OBJECTIVE: Develop a portable, non-contact digital system for detecting failure initiation and propagation, and load intensity in structural composite joints in real time.

DESCRIPTION: The total ownership cost for air vehicles, both manned and unmanned (including weapons) can be reduced if the structural components have lower weight, improved structural integrity, and lower parts count. This can be accomplished by utilizing fiber-reinforced composite bonded joints and joints with woven inserts in the design and manufacture of the structural components. Efficient and reliable design of composite bonded joints requires thorough understanding of failure (e.g. delamination, fiber breakage) mechanisms and bond strength. Composite joints can only be used if we can predict the failure initiation and propagation and load intensity in the joints in real time. Tools are needed for validating the predicted results and developing the most efficient and reliable composite joints.

For example, in highly loaded composite structures, failure may start at several places simultaneously. X-rays can provide visualization of the whole field, and can be used to locate several failure locations simultaneously. This experimental information is of great value for developing optimized composite structures. The portable, non-contact digital X-ray system can be used to design and develop efficient structural composite joints. With proper modifications and calibration, it can also be used for damage assessment, inspection, and corrosion detection on carriers, in depots, and in the field. The technology will also have potential use for the medical field, airport security, and detecting illegal drugs.

Phase I: Perform a feasibility study for detecting (2D and 3D) failure (e.g., delamination, fiber breakage) initiation and propagation, and load intensity at failure locations in representative test specimens in real time. The specimens should be fiber-reinforced composite lap joints and joints with woven inserts. The system should be portable, have spatial resolution of the order of 15 line pairs per millimeter, contrast sensitivity of the order of 0.2%, and make no contact with the specimens.

Phase II: Based on the feasibility study in Phase I, develop a portable system with appropriate software, and perform extensive tests on various composite lap joints and joints with woven inserts. The testing should document digitally (2D and 3D) the failure initiation and propagation and load intensity at failure locations in the specimens. The test data will be utilized to validate the failure analyses by government/industry laboratory personnel. The system should also have the capability for damage assessment and inspection on carriers, in depots, and in the field.

Phase III: Transition the technology to the government and commercial communities for structural damage assessments, corrosion detection, and nonmetallic, polymeric and organic material identification.

COMMERCIAL POTENTIAL: The proposed system could be used for airport security, medical applications, corrosion detection in offshore pipelines, and identifying illegal drug identification.

Key words: Composites; Bonded; Joints; Woven; Inserts; Failure; Damage; Inspection; Digital

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Why are we proposing this topic: The Navy has a compelling need to reduce the total ownership cost without lowering safety and readiness. This can be accomplished to a considerable extent by utilizing composite bonded joints, and joints with woven inserts in the design and manufacture of the structural components for air vehicles, both manned and unmanned (including weapons). A high resolution, portable, non-contact digital X-ray system would allow a designer to obtain experimentally failure initiation and propagation in real-time. These are needed to develop the most efficient composite structural components with joints. Composite structural components with bonded joints, and joint with inserts will be thinner, and will have lower weight and parts count. This will reduce the assembly time and cost. The portable, non-contact digital X-ray system that will be developed for the experimentation can also be used, with proper modifications, for damage assessment and inspection on carriers, in depots, and in the field.

Total Ownership Cost Reduction: The technology has the potential for reducing the ownership cost of manned and unmanned vehicles (including weapons) by reducing the weight, complexity, and parts count of critical structural components. The composite structural components designed and manufactured with bonded joints and joints with woven inserts will have a lower parts count, thereby reducing the assembly time, manpower, and maintenance cost. A portable, non-contact, high-resolution X-ray system can be used for damage assessment and inspection on carriers, in depots and in the field without fully disassembling the hardware. This will reduce maintenance cost and increase safety of flight. It is estimated that both the weight and total ownership cost can be reduced by up to 30% depending on the applications.

Category: Exploratory development

Science/Technology Area: Aerospace Vehicles; Materials, Processes, and Structures; Surface/Undersurface Vehicles/Ground Vehicles; Mechanics.

Navy Requirement: (In accordance with STRG, August 1998)

Air Warfare - Platforms - Requirement # 3.2.b.1, 3.2.d	(Page 39)
Logistic Support - Maintenance - Requirement # 8.1.b, 8.1.a, 8.1.c.4	(Page 112)
Logistic Support - Infrastructure - Requirement # 8.7.a.3	(Page 121)
Logistic Support - Linkages to Other Functional Areas - Requirement # 9.3.a	(Page 135)

PRODUCT LINE TEAM AREA: Aircraft, Weapons, Integrated Support Systems

SPONSOR: PMA-275, PMA-280, PMA-258, PMA-208, JSF

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Priority Number:

TITLE: Selective Depainting and Precision Cleaning

OBJECTIVE: To develop a capability for the selective depainting of Navy aircraft and to clean precision instruments and equipment.

DESCRIPTION: Recent advances in ultrasonic technology show significant promise for depainting, and cleaning critical equipment using non-hazardous materials. All of this occurs without any damage to the underlying substrate. Currently, there is a need for an environmentally friendly method for the selective depainting of aircraft to remove the 10-15% of paint remaining after the use of flash jet and other technologies. Such a method has a second potential application for the precision cleaning of gyroscopes, bearings, and other components without the need for volatile solvents or hazardous chemicals.

Phase I: Demonstrate depainting and precision cleaning in a laboratory setting. Design a system to scale up the process for rapid depainting of various types of paints on common aircraft surfaces. Estimate the speed of depainting based on results. Explore a method for precision cleaning of aircraft and crew systems equipment.

Phase II: Build and test a prototype system and conduct full-scale tests to demonstrate the feasibility for depainting or cleaning Navy aircraft and equipment. Conduct full-scale precision cleaning tests for applications identified in Phase I.

Phase III: Customize and implement the Phase II work for appropriate Navy aircraft and ship programs and for commercial aircraft.

COMMERCIAL POTENTIAL: An efficient, environmentally friendly method for de-painting has applications to commercial aircraft as well as to both Navy and commercial ships, engines and manufacturing equipment. Applications in cleaning include industrial, medical and commercial applications where removal of contaminates on critical surfaces or life support equipment is needed. The transition should occur rapidly after the process is validated for Navy aircraft and ships.

References:
1. SAE MA4872

Key words: Environmentally Friendly; Depainting; Selective; Precision Cleaning

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Why are we proposing this topic: This effort will provide a needed environmentally friendly depainting and cleaning capability for Navy aircraft, and secondarily for Navy ships.

Category: Exploratory development

Science/Technology Area: Aerospace Vehicles; Materials, Processes, and Structures

Navy Requirement: Environmental Quality (13.3.b)

Total Ownership Cost Reduction: Ownership cost reductions will be realized as a result of reduced labor hours to strip paint and reduction of waste material and disposal (including hazardous materials), reduced worker exposures to hazardous materials, and compliance with environmental legislation.

PRODUCT LINE TEAM AREA: Aircraft

SPONSOR: PMA-290, PMA-299, JSF

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Priority Number:

TITLE: Innovative Protective Coating Systems for Aircraft

OBJECTIVE: Find a single-component, protective coating system for use over aircraft surfaces which does not require pretreatment, a primer, and/or a topcoat. The technology shall meet the performance requirements of TT-P-2756, MIL-P-23377, MIL-P-85582, MIL-PRF-85285, and AMS 3603.

DESCRIPTION: Navy aircraft finishing systems for aluminum consist of an inorganic surface pretreatment (chromated, conforming to MIL-C-81706) followed by a series of organic coatings: primer (conforming to MIL-P-23377 or MIL-P-85582) and topcoat (conforming to MIL-PRF-85285). The surface pretreatment enhances corrosion inhibition and adhesion to the primer. The primer contains additional corrosion inhibitors and provides an adhesion layer for the topcoat. The topcoat provides chemical and weather resistance, as well as flexibility and the required optical properties. Although this finishing system has been the premiere finishing system on aircraft for many years, it has several deficiencies. Increased awareness and concern for environmental issues as well as worker safety have caused local, state, and federal agencies to limit volatile organic compound (VOC) and hazardous air pollutant (HAP) emissions. The majority of corrosion inhibitors found in pretreatments and primers are hexavalent chromates; these have been identified as human carcinogens. VOCs have been attributed to the production of ground-level ozone and smog. These issues have demonstrated the need to develop an environmentally friendly, single-component coating system.

Phase I: Provide an initial development effort that combines nontoxic corrosion inhibitors with a binder system to produce a single-component coating for use on Navy aircraft. The coating must meet the current military and performance specifications as well as be compatible with existing materials. Additionally, the application of the proposed coating should not interfere with the logistical and operational requirements of the naval facility tasked to use the coating.

Phase II: Refine, test, and field demonstrate the coating developed under the Phase I effort.

Phase III: Produce the coating demonstrated in the Phase II effort. The coating will be transitioned to the Fleet through specification modifications and revisions to aircraft weapons system technical manuals. If further development and/or field-testing are require, aircraft programs funding or W2210 funds will be pursued.

COMMERCIAL POTENTIAL: A non-hazardous, single-component coating system can be used on commercial aircraft as well as non-aerospace applications for both the government and private sector, making this technology directly transferable.

References:

1. MIL-C-81706
2. MIL-P-23377
3. MIL-P-85582
4. MIL-PRF-85285
5. TT-P-2756
6. AMS 3606

Key words: Environmentally Friendly; Coating System; Single Component; Pretreatment; Primer; Topcoat

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Why are we proposing this topic: This effort will provide a single-component, environmentally friendly coating system for use on naval aircraft. Some benefits are as follows: (1) eliminate hand/mechanical, chemical, and/or sand-blast stripping of protective coatings; (2) increased level of ease of fleet or field level repair of these coatings; (3) increased level of ease of application of these protective coatings; and (4) minimization of waste and hazardous material usage.

Category: Exploratory development

Science/Technology Area: Aerospace Vehicles; Materials, Processes, and Structures

Navy Requirement: Environmental Quality (13.3.b)

Total Ownership Cost Reduction: Ownership cost reductions will be realized through reduced painting and depainting costs, materials waste and disposal (including hazardous materials), reduced worker exposures to hazardous materials, compliance with environmental legislation, and avoidance of implementing expensive pollution-abatement equipment.

PRODUCT LINE TEAM AREA: Aircraft

SPONSOR: PMA-275, PMA-290, PMA-299

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Priority Number:

TITLE: Non-Chromated Flexible Primer

OBJECTIVE: Develop a primer for aircraft applications that contains no chromated corrosion inhibitors and exhibits exceptional flexibility.

DESCRIPTION: The Navy and the Air Force currently use a flexible primer as the primary component of the corrosion-prevention finishing system on various aircraft (e.g. E-2/C-2, H-53, large cargo aircraft). This step is necessary to prevent film cracking at low temperatures (-60°F) and subsequent corrosion primarily at high-flexing components and fastener patterns. The current flexible primer contains chromated corrosion inhibitors; these compounds have been identified as carcinogens and elimination of their use has been mandated at all levels of government, especially in southern California. This is particularly crucial because most Navy rework involving high-flexing aircraft is performed at the Naval Air Depot, North Island, which is located near San Diego.

Phase I: Provide an initial development effort that incorporates nontoxic corrosion inhibitors into a polymeric binder system to produce a sprayable, flexible coating for use on Navy aircraft. The coating must meet the current military specification as well as be compatible with existing pretreatments and topcoats. Additionally, the application of the proposed coating should not interfere with the logistical and operational requirements of the naval facility tasked to use the coating.

Phase II: Develop, test, and field demonstrate the coating formulated under the Phase I effort.

Phase III: Produce the coating demonstrated in the Phase II effort. The coating will be transitioned to the Fleet through specification modifications and revisions to the aircraft weapons system technical manuals. If further development and/or field-testing are required, aircraft program funding or demonstration programs funds will be pursued.

COMMERCIAL POTENTIAL: Successful coating can be used on commercial aircraft as well as on other DOD aircraft.

References:
1. TT-P-2760
2. MIL-C-85285
3. MIL-C-81706/5541
4. TT-P-2756

Key words: Primer; Coating; Non-Toxic; Chromates; Flexible

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Why are we proposing this topic: This effort will provide a nontoxic flexible primer for naval aircraft. The need exists for corrosion protection of aircraft prone to flexing stresses without the use of carcinogenic chromated corrosion inhibitors. Their use will be severely limited by the end of FY 1998.

Category: Advanced development

Science/Technology Area: Aerospace Vehicles; Materials, Processes and Structures

Navy Requirement: Environmental Quality (13.3.b)

Total Ownership Cost Reduction: Reductions in ownership costs will be realized through the following: the avoidance of expensive hard controls for pollution abatement; avoidance of fines for noncompliance; reduced hazardous waste disposal costs; and improved worker safety and health.

PRODUCT LINE TEAM AREA: Aircraft

SPONSOR: PMA-299, JSF

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Priority Number:

TITLE: Innovative Thermal Barrier Technology for Exterior Aircraft Structures

OBJECTIVE: Develop a thermal barrier technology that can easily be applied to exterior aircraft structures. The technology should prevent premature hardware failure due to localized overheating and should meet a thermal insulation requirement for target applications. The technology insulation requirement is aircraft dependent, with potential short-term thermal excursions as high as 800^0F (60 seconds), and long-term exposure at 285^0F (duration of flight). Depending on substrate materials, the substrate operation time could be as high as 325^0F or as low as 200^0F.

DESCRIPTION: During certain flight and/or ground operations on several types of aircraft, exterior structures and components are exposed to engine exhaust. These structures and components were not designed for these errant non-flight profile cyclic temperature profiles. As a result they are in need of premature repair or replacement. A thermal barrier technology composed of environmentally responsible materials with low toxicity is sought for protection from transient temperature excursions. Furthermore, a thermal barrier technology that is easy to apply and remove at both field and depot level is needed to minimize heat conduction. The developed protection system must not inhibit the use of standard depot nondestructive inspection techniques for evaluating the integrity of the underlying substrate.

Phase I: Develop a thermal barrier protection concept that can be applied to the exterior surfaces of aircraft and withstand the dynamics of airflow during typical flight operations. Zero volatile organic compounds (VOC) emitter, non-organic hazardous air pollutant (HAPS) and single-component should be target properties of the thermal barrier protective coating. In addition, the coating should have an ambient temperature cure and storage (not mandatory). The technology's thermal conductivity properties should be defined. In addition this technology should meet all local, city, state, and federal environmental regulations. The fluid resistance, humidity resistance, adherence properties and flexibility must meet the performance requirements of AMS 3603, MIL-PRF-85285, and/or TT-P-2756. Preliminary laboratory testing will demonstrate the feasibility of this technology as thermal protection for its target application (exterior aircraft structures and components).

Phase II: Further develop the technology to meet the objectives of the Phase I results and conduct laboratory testing to further characterize the properties of the materials. The laboratory testing will provide adhesion characteristics, thermal conductivity, hot/wet thermal cycling, nondestructive inspection characteristics, and failure mode characteristics. If possible, conduct flight testing of the material on an aircraft.

Phase III: Production of the technology demonstrated in Phase II of this effort should be demonstrated and studied for both the military and commercial markets. If further development and/or field-testing are required, aircraft program or demonstration program funds will be pursued.

COMMERCIAL POTENTIAL: This technology can be transitioned to commercial aircraft as well as non-aerospace applications for both the government and private sectors.

References:

1. AMS 3603
2. MIL-PRF-85285
3. TT-P-2756.

Key words: Thermal Barrier; Thermal Insulation; Aircraft Surfaces

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Why are we proposing this topic: The Navy has several types of aircraft where engine exhaust either damages or reduces the fatigue life of structure/component. Examples are AV-8B strake and flap, and E-2/C-2 wing.

Category: Basic research, Exploratory development

Science/Technology: Aerospace Vehicles; Materials, Processes, and Structures

Navy Requirement: Environmental Quality (13.3.b)

Total Ownership Cost Reduction: This technology has the potential of reducing total ownership cost by eliminating/reducing repair and replacement costs caused by overheating. Where aircraft structural fatigue life has been reduced due to engine exhaust exposure, fatigue life may be increased.

PROJECT LINE TEAM AREA: Aircraft

SPONSOR: PMA-290, PMA-231, JSF

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Priority Number:

TITLE: Design Assistant and Software Tools for System Identification and Adaptive Fault-Tolerant Control

OBJECTIVE: : Enhance the maneuverability and survivability of aircraft under adverse conditions such as battle damage and critical system failures using on-line system identification (SI), Health Monitoring and Failure Detection and Identification (HM-FDI), and Adaptive Fault-Tolerant Control (AFTC)

DESCRIPTION: Future combat aircraft will be expected to operate outside currently achievable flight envelopes and achieve desired flying qualities in the presence of large uncertainty, severe subsystem failures, battle damage and large unanticipated disturbances. In addition, the dynamics of the aircraft under aggressive maneuvers are highly nonlinear. While some results related to aircraft HM-FDI, disturbance estimation and rejection, AFTC and structure and parameter estimation using efficient SI techniques are available in the existing literature, many of the important related problems have not been addressed. These include:

1. How to determine the sensitivity of the overall closed-loop system to different failures and disturbances?

2. How to model and parameterize different types of failures and structural damage?

3. How to relate the available redundancy to failure accommodation and disturbance compensation?

4. How to address the problem of severe single and multiple failures that cannot be handled using existing methods?

5. How to achieve fast and accurate on-line identification of aircraft flutter and rigid body modes and uncertain aircraft parameters?

6. How to effectively combine the on-line nonlinear SI techniques with HM-FDI and robust controllers to arrive at a highly efficient AFTC system for failure accommodation and flutter suppression?

In addition, a software tool is needed to aid the flight control designers in the design of HM-FDI, AFTC systems and SI techniques.

Phase I: Design integrated HM-FDI and AFTC algorithms for an aircraft model under battle damage, sensor/actuator failure conditions, and parametric uncertainties. Demonstrate the viability of the algorithms and stability, robustness and performance of the overall closed-loop system. Test adaptive fault-tolerant controllers on an aircraft model for different critical maneuvers under failures and parametric uncertainties. Design new and unique SI techniques for fast and accurate on-line estimation of flutter and rigid body modes and uncertain aircraft parameters. Develop a conceptual solution for the HM-FDI and AFTC design toolbox.

Phase II: Demonstrate the features of the software tool using hardware-in-the-loop simulations. Carry out further validation, including in-flight testing, of the SI, HM-FDI and AFTC software. Make detailed plans for Phase III commercialization and transition

Phase III: Apply tool box to solve Navy aircraft fleet problems or aircraft performance enhancement. Demonstrate this improved design through simulation and then flight test. The flight test demonstration for a high-performance aircraft will be accomplished using the research flight control computer developed for the F-18 ABCD aircraft (fleet support flight control computer (FSFCC)). Incorporate tool box into commercial software for use by automotive industry, commercial aircraft companies, biotechnology industries, etc.

COMMERCIAL POTENTIAL: The toolbox could be incorporated into commercial software for use by automotive industry, commercial aircraft companies, biotechnology industries, etc.

References:

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6. J. D. Boskovic, "A Multiple Model-Based Controller for Nonlinearly-Parametrized Plants", in Proceedings of the American Control Conference, Vol. 3, pp. 2140-2144, Albuquerque, NM, June 1997.

Key words: Adaptive Control; Health Monitoring; Failure Detection; Failure Identification; Adaptive Fault-Tolerant Control and System Identification

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Why are we proposing this topic: This topic addresses the critical technology area of Damage Adaptive Flight/Propulsion Control. The successful development of this technology will reduce the loss of fleet aircraft due to flight control system battle damage or system failures.

Total Ownership Cost Reduction: Cost reductions will be realized through reductions in loss of aircraft and accidents due to battle damage or systems failures in aircraft flight control systems. Considering the following aircraft platforms, F-18 C/D, F-18 E/F, V-22, F-14 and S-3, it is estimated that at least three class

A mishaps could be prevented each year. This would result in savings of approximately $87,000,000 in lost aircraft each year. Over a ten year period $870,000,000 in aircraft losses would be saved.

Category: Basic research, Exploratory development

Science/Technology Area: Aerospace Vehicles; Modeling and Simulation; Computers, Software; Electron Devices; Computer Science; Electronics

Navy Requirement: 3.2.a

PRODUCT LINE TEAM AREA: Aircraft, Avionics and Sensors

SPONSOR: PMA-290, JSF

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Priority Number:

TITLE: Weight Efficient Corrosion Resistant Composite Heat Exchangers

OBJECTIVE: Develop a weight efficient composite heat exchanger for the V-22, capable of withstanding a high temperature, corrosive environment.

DESCRIPTION: The Navy has an immediate need for an alternative to the metallic environmental control system (ECS) primary and secondary heat exchangers currently being utilized on the V-22. The primary and secondary heat exchangers cool high temperature air that is the power source for the ECS. The existing metallic designs are weight inefficient, and may be prone to oxidation and corrosion degradation. Metallic heat exchangers utilized on other aircraft, such as the F-18, have a long history of corrosion and oxidation related problems. The unique requirement that Navy aircraft operate in a salt prone environment compounds these issues. The environment induced damage mechanisms have led to reductions in the life expectancy of the heat exchanger components, and resulted in significant fleet maintenance burdens. The end result is an increase in life-cycle costs associated with the aircraft. Advanced high-temperature composite materials such as carbon-carbon and ceramic matrix composites (CMC's) may provide the necessary solution for the life extension of these components. Carbon-carbon has been demonstrated to withstand a high-temperature environment and can be designed to exhibit a high thermal conductivity. CMC's, although typically thought of as insulators, may provide higher resistance to oxidation and a corrosive environment.

Phase I: Demonstrate feasibility by designing, fabricating, and testing prototype composite sub elements representative of a V-22 primary or secondary heat exchanger. Provide preliminary data, which indicates the ability of the design to withstand the harsh environment. Analytically show that the proposed concept provides the required thermal performance and meets the structural requirements as well.

Phase II: Develop the detailed design of a complete V-22 primary or secondary heat exchanger, including attachment concepts and fabrication methods. Demonstrate produceability by fabricating a full scale V-22 primary or secondary heat exchanger. Demonstrate the ability of the design to withstand the hot corrosive and oxidation environment. Evaluate the performance of the component under realistic simulated flight conditions.

Phase III: Utilize the developed V-22 heat exchanger design and fabrication methods to transition the technology to other aircraft and other heat exchanger configurations.

COMMERCIAL POTENTIAL: Advanced composite heat exchanger components have the potential to transition to the commercial aircraft market for weight reduction and enhanced life expectancy.

References:

Key words: Heat Exchanger; V-22; Composite Materials; Carbon-Carbon; Ceramic Matrix Composites

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Why are we proposing this topic: This effort will develop designs for lightweight, corrosion and oxidation resistant heat exchangers for the V-22. These designs will transition to heat exchangers on other Navy aircraft, such as the F-18, which are experiencing environmental degradation and premature failure.

Total Ownership Cost Reduction: Development of weight efficient heat exchangers will reduce the life-cycle costs associated with increased maintenance and premature replacement of existing metallic heat exchanger components.

Category: Exploratory development

Science/Technology Area: Materials, Processes and Structures

Navy Requirement: Air Warfare; Platforms, 3.2.b

PRODUCT LINE TEAM AREA: Aircraft

SPONSOR: PMA-275, JSF

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Priority Number:

TITLE: Low Cost Turbojet Engine for Expendable Target Applications

OBJECTIVE: The US Navy is interested in exploring the potential of low cost turbojets to fulfill the propulsion requirements of future aircraft target systems. Current radio controlled (RC) hobby aircraft use inexpensive turbojet engines that generate up to 40 pounds of static thrust, which is less than our envisioned future requirements. We are interested in either new engines using current hobby engine technology or increasing current hobby engine performance > 160 pounds of maximum static thrust, or the simultaneous use of two engines generating >80 pound of static thrust each. These engines will be expected to operate in target aircraft that operate in a salt air environment. Target flights do not typically exceed 60 minutes, operate for a maximum of five flights, and use JP-5/JP-8 fuel during these flights. They should start by use of compressed air into the engine's compressor to reach a minimum self-sustaining operating RPM, and should provide maximum thrust, without degradation, over the expected life of 200 minutes. The cost goal for each target propulsion system is <$10,000.00 (in current 1998 dollars) in production runs of not less than 200-250 engines.

DESCRIPTION:

Phase I: Provide an in-depth study characterizing current RC aircraft turbojet performance (thrust, fuel consumption, operating temperatures), along with a detailed design study of potential changes and improvements that meet both the performance and cost objectives listed above.

Phase II: Execute an engine modification, or prototype production program for selected engines, utilizing the design study of Phase I. Perform sea level performance and reliability/durability testing on these engines to demonstrate minimum performance based upon Phase I projections.

Phase III: Provide production representative engines to airframe manufacturers for low cost target program.

COMMERCIAL POTENTIAL: Success through Phase III will provide hardware that could be modified for turboshaft and turbofan applications for both civil aviation and ground applications (gen-sets, automotive, etc)

References: None

Key words: Turbojet; Target

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Why are we proposing this topic: After discussion with PMA 208 about a future, low cost target program, we concluded that an innovative approach to reduce propulsion system cost would be necessary, and should be started in 1999. Target aircraft use engines that exceed the objective cost by six times. Current RC turbojet engines cost approximately $6000, so a $10000 engine based on this technology is feasible. Propulsion system cost reduction to only 5-10% of overall target cost will result in more target presentations being possible for pilots.

Total Ownership Cost Reduction: For an engine production run of 500 engines, the cost reduction for the propulsion system would be approximately $25M.

Category: Exploratory development

Science/Technology Area: Aerospace Propulsion and Power

Navy Requirement: 1-.1.c

PRODUCT LINE TEAM AREA: Aircraft

SPONSOR: PMA-208

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Priority Number:

TITLE: Motion Coupling in a Deployable Virtual Environment Trainer

OBJECTIVE: Develop strategies and methods for linking real-world motion with perception in a virtual environment

DESCRIPTION: The military's vision of deployable training systems introduces a novel problem for application of virtual environments (VE) in these settings. Cybersickness, a type of motion sickness particular to immersion in a VE, is produced by discordance between the perception of motion in the VE and lack of actual motion. A deployed VE trainer would have the additional difficulty of having actual motion discordant with VE perceived motion (rather than a lack of motion). This could substantially limit the usefulness of deployed VE trainers. One possible method of combating this perceptual discordance is to include the actual real-world motion in the VE. This would require motion information from the deployed platform (such as a ship or aircraft) to be transmitted to and incorporated in the virtual environment. This could be especially useful for tasks in which the actual motion is a true part of the task (such as for a conning officer or landing signals officer).

Phase I: Identify and develop methods and techniques to effectively couple actual motion with perceived VE motion. Hardware and software requirements will be defined and established with consideration given to potential deployment platforms (such as ships) and human performance requirements (such as lag time).

Phase II: Implement the design requirements identified in phase I in a test bed for an identified Navy application.

Phase III: Based on a successful Phase II effort, refine the test bed into a product suitable for commercial and military applications.

COMMERCIAL POTENTIAL: This technology would enable effective use of virtual environments on any moving platform (such as ships, aircraft, hovercraft, land transportation, etc.).

References:

(1) Burkicohen J. Soja NN. Longridge T. "Simulator platform motion – the need revisited." *International Journal of Aviation Psychology*. 8(3):293-317, 1998.

(2) DiZio, P., Lackner, J.R. "Spatial orientation, adaptation and motion sickness in real and virtual environments." *Presence,* 1(3):319-328, 1992.

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(4) (4)Kennedy RS. Berbaum KS. Lilienthal MG. "Disorientation and postural ataxia following flight simulation." *Aviation Space & Environmental Medicine*. 68(1):13-17, 1997 Jan.

(5) (5)Lackner, J.R. "Human Orientation, Adaptation, and Movement Control. In: Motion sickness," *Visual Displays, and Armored Vehicle Design*, National Research Council, Washington, D.C. National Academy Press, Washington, D.C., 29-50, 1989.

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Key words: Virtual Reality; Training; Motion Simulation; Simulation; Cybersickness; Motion Sickness

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Why are we proposing this topic: Virtual environments have been identified as a tool that can significantly enhance and facilitate training and potentially improve fleet readiness. The desire to implement deployed VE systems is challenged by the difficulties in addressing cybersickness and perceptual discordance due to the motion of the training platform (such as a ship). Creating a means of matching true motion to a VE could enable the effective implementation of deployed VE systems.

Total Ownership Cost Reduction: This SBIR could develop a means for effectively realizing deployable VE training systems. The efficacy of deployed VE training systems could be severely compromised without coupling actual motion with the perceived VE motion feedback.

Category: Exploratory development

Science/Technology Area: Modeling and Simulation; Manpower; Personnel and Training Systems; Human-System Interfaces

Navy Requirement:
(1) 10.1.a. Innovate and optimize instruction (achieve greater levels of expertise in less time) - *High*
(2) 10.1.d. Develop models, methods, techniques, simulations, etc. to reduce/eliminate training requirements and costs- *High*
(3) 10.1.g. Develop models and technologies to optimize the human ability to learn -*Medium*
(4) 10.1.i. Enhance our ability to provide deployed individual and team training. - *Low*

PRODUCT LINE TEAM AREA: Training, Simulation and Modeling.

SPONSOR: PMA-205

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Priority Number:

TITLE: Alternate Time Management Schemes for Use in High Level Architecture (HLA) Federate Simulation

OBJECTIVE: Enabling joint force exercises to occur through the linking of military training simulators would reduce the operation and maintenance costs of the weapons systems involved by at least an assumed 20 to 30 percent. Specifically, this topic seeks to develop software architecture capable of interfacing with federated simulations to demonstrate timing and latency compliance in a jointly scripted mission scenario. The architectural model for processing simulation data transfer messages will be in accordance with the federate and object templates and HLA compliance rules. To the maximum extent feasible, the solution should be based upon the utilization of standardized components, such as the management object model (MOM), data interchange format (DIF), and data dictionary (DD), rather than customized extension solutions.

DESCRIPTION: The Navy is vigorously increasing its use of modeling and simulation to improve war fighting skills in a peacetime environment and to develop superior capable weapon systems. To this end, the DOD initiative establishing HLA simulation has directed the Services to guarantee inter-operability of federated simulation models and allow reusability based upon both common interfacing and separation of message data handling from object model functionality. Thus the system models developed can provide federated mission oriented training capability with the required fidelity to train crews in a total tactical environment. This will involve networking of joint simulations including full man-in-the-loop aircraft simulators configured for mission scenario training such as Navy: F-14; F-18; E-2; EA-6; Air Force: USN CV; F-22; F-16; USAF conventional takeoff and landing (CTOL); Marine Corps: F/A-18; AV-8B; STOVL; in joint strike scenario tactics. Present aircraft simulators do not support mission synthetic training because no provision enables the inter-operability required for networking that does not follow a common message protocol.

Although distributed interactive systems (DIS) provided such a common protocol at a message broadcast rate, large bandwidth requirements often resulted in data latency. In contrast to DIS interface standards, HLA allows for a choice of interface time management schemes for message traffic between federated simulation models that may reduce bandwidth requirements. In order to implement interpretable federates with compatible message transfer which minimize delay or latency in tactical event timing, a time management scheme must be chosen which complements the data transfer requirements. HLA has a mechanism in place that is well suited for addressing this sort of thing -- MOM. In addition to the MOM, there are other standards, or standard pending mechanisms, that can be of use in this area of research. These mechanisms include DIFs and the DD under development by the Defense Management and Simulation Office (DMSO). However, many of those who have looked at event/timing management, have implemented solutions based upon their own customized federation object model (FOM) extensions. Rather than develop another customized FOM extension solution, perhaps a more desirable approach (more conducive to generic inter-operability) is to implement a solution that is based upon utilization of standardized components, such as the MOM, DIFs, and DD, to the maximum feasible extent. A study is needed of the mission training message data requirements and their impact upon message transfer rates and upon the simulation message processing architecture and data base design. Alternate message architecture and timing management must be investigated to provide the basis for selection of schemes meeting federate requirements.

Phase I: Investigate mission federate data transfer requirements in the context of scenario events and options and the alternate message time management schemes that might meet data transfer and latency requirements. The project must investigate use of filtering schemes (using MOM or DDM). Also, Naval Air Warfare Center, Training Systems Division in-house developed software, Simulation and Modeling Object Classes/Common Interoperability Mechanism (SMOC/CIM) should be included in the Phase I review. A conceptual, message timing and processing architecture will be postulated and mapped to a software structure. It is expected that problem areas identified in the literature would be identified and documented for inclusion in the Phase II effort.

Phase II: Implement the message timing management scheme by prototyping the architecture software and interfacing with federated simulations for demonstration of timing and latency compliance in a jointly scripted mission scenario; i.e., implement a filtering using MOM, DIFs, DD, or even DDM. The architectural model for processing simulation data transfer messages will be described in accord with the federate and object templates and HLA compliance rules. Research into how different time management schemes could be used within a single federation or how the protocols could be designed to accommodate different simulation types but merge to a single time management scheme should also be conducted.

Phase III: A transition filtering scheme to a naval simulation would be made to include naval surface simulation, Army and Marine Corps simulated ground forces and helicopter support, and command and control simulations. Commercial transitions are anticipated to occur as well.

COMMERCIAL POTENTIAL: FOMs can be written for a wide variety of applications far beyond the military's simulated weapons platform interactions. For example, the HLA message timing management scheme could enable logisticians to assess the impact of new support models on an existing (simulated) delivery system faster than real time. Accountants may wish to test the effects of new cost models on a simulation-based acquisition process. Manufacturers designing new plants could have their assembly-line designs tested and analyzed by adding suppliers' virtual models of sub-assembly stations and robotic concepts to their virtual assembly-line prototype model. Moreover, with a standardized architectural model for processing simulation data transfer messages, it is possible that any of the models just described could be combined as needed for any number of yet-to-be identified simulated tests.

References:

(1) Simulation Interoperability Workshop (SIW); http://www.sisostds.org/siw/98spring/rpts-papers.htm
(2) Sell, S. Ronald. 98S-SIW-049 "Federation Management: Using MOM and FOM Data to Manage the Federation"
(3) Braudaway, Wes. 98-SIW-107 "Synchronized Player Models For Embedded Training"
(4) Hopkins, Mike. 98-SIW-251 "Order of Battle Data Interchange Format and Access Tool"
(5) Dale Mace, Russell. 98F-SIW-058 "A Composite HWIL/Event Driven Federation For Mine Warfare Analysis"

Key words: High Level Architecture; Federated Simulation Models; Federation Object Model, Simulation, Modeling, DIS.

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Why are we proposing this topic: The DOD initiative establishing HLA has directed the Services to guarantee interpretability of federated simulation models and separation of message data handling from object model functionality. Present aircraft simulators do not support joint mission synthetic training, and current HLA efforts seldom consider how future JSF platforms would be included in these synthetic environments. While current players in this arena have developed customized FOM extension solutions, this SBIR should stimulate other approaches that may be more conducive to generic inter-operability with more of an international and forward-looking solution.

Total Ownership Cost Reduction: The DOD initiative establishing HLA has directed the services to guarantee interpretability of federated simulation models and separation of message data handling from object model functionality. Present aircraft simulators do not support joint mission synthetic training, and current HLA efforts seldom consider how future JSF platforms would be included in these synthetic environments. Developing the capability to effectively perform simulated joint forces tactical training exercises by linking military training simulators, would reduce the operations and maintenance costs of the respective weapons systems involved by at least an assumed 20 to 30%.

Category: Exploratory development.

Science/Technology Area: Manpower, Personnel and Training Systems

Navy Requirement: X.1.a. (High):

PRODUCT LINE TEAM AREA: Training, Simulation and Modeling

SPONSOR: PMA-205, JSF

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Priority Number:

TITLE: Client/Server Part Task Trainer Interface

OBJECTIVE: Develop a client/server interface and supporting client and server software to enable a helicopter part task trainer (PTT) emulation to function in a standalone or in an internet server interactive training mode. Develop server and distributed embedded client PTT software to enable bi-directional synchronous and asynchronous data transfer over the Internet. These Internet data transfers will enable server administrative management of single or multiple remote site PTTs concurrently. This capability sequentially leads the way for aircraft representative collaborative training for military aircrews, synthetic warfare, and commercial aircraft operations.

DESCRIPTION: The Navy has fielded multiple helicopters PTTs that emulate a variety of aircrew control display units (CDUs). These CDU emulations (CDUEs) reflect unique operational flight program (OFP) functionality for specific types of aircraft. Several Navy helicopters use common CDU hardware; however, some use unique CDU hardware with a unique faceplate design and a unique OFP (e.g., AH-1W Cobra helicopter). The mission functionality in each CDU (common or not) is unique to each aircraft platform, and is representative of the implemented hardware and the resident OFP. However, the objective of each CDUE is common – to provide aircrew training using an aircraft representative man/machine interface. Current PTTs that host CDUEs are stand-alone systems under full control of the trainee. Training objectives that cannot be met with a stand-alone PTT include instructor initiated fault insertion, and interactive training operations with remote site users in a common theater of operation (collaborative training). Expanding CDUE functionality to enable server connectivity with an embedded data transfer interface is required. This distributed CDUE environment will support incremental expansion of mission training in a multi-aircraft environment.

Phase I: Conduct in-depth analysis and provide proof of concept that a CDUE can host and support an embedded network communication application in a client/server mode transparent to the user. This interface must provide scheduled and unscheduled CDUE-to-server and server-to-CDUE data transfers in a background mode. The aircrew interface must remain aircraft representative during all modes of training operations.

Phase II: Continue with the concept developed in Phase I and develop a prototype system. Demonstrate the operation and feasibility of using multiple CDUEs to perform collaborative mission functions (e.g., establish single-channel ground airborne radio system (SINCGARS) link between two aircraft) and server initiated fault insertion.

Phase III: Produce PTT and server software applications that comprise an embedded client/server interactive PTT system. This interactive system will be the basis for further development and production of PTT systems for all Navy aircraft.

COMMERCIAL POTENTIAL: Avionics similar to the CDU are utilized in a variety of commercial aircraft. As the FAA approaches implementation of "Free Flight", collaborative multi-aircraft aircrew training requirements will increase as aircraft traffic management transitions from ground based controllers to aircraft avionics control. Commercial aircrew training systems will share the same cost savings advantages as DoD with the fielding of this system. Training for collaborative processes or procedures is seen to capitalize on the technology implemented in this system.

References:
(1) AH-1W Cobra 1A Human Interface Document
(2) AH-1W Cobra 1A Functional Requirements Document
(3) AH-1W Cobra 1A System Specification.

Key words: PTT; CDU; Server Client Interface; Interactive Collaborative Training; Internet

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Why are we proposing this topic: Operational missions often require collaboration of multiple helicopters, which can comprise multiple helicopter types (UH-1N, AH-1W, H-53, H-60, etc.) Collaborative operations require inter aircraft communications and control using the CDU as the aircrew interface with the aircraft avionics systems. Incorporating the technology identified in this topic facilitates real multi aircraft mission training. Moreover, this technology enables fault insertion to be "pushed" into the training environment. Successful execution of this topic enables the Navy to deploy operationally representative systems that train fleet aircrews for real world mission scenarios.

Total Ownership Cost Reduction: Costs are greatly minimized through creative embedding (and integrating) of COTS software objects to realize new functional capabilities. Moreover, topic products have the potential to integrate into larger training environments as software objects themselves. Through product documentation and registration, this topic supports code reuse.

This topic proposes no hardware development to realize this added functionality. All hardware supporting the developed software is IT-21 COTS. This reduces the cost increasing the affordability of realizing the addressed functionality.

Category: Exploratory development

Science/Technology Area: Manpower, Personnel and Training Systems

Navy Requirement: Navy STRG Requirement 10.2.b.5, Training, Instruction Delivery, Increase interoperability for joint training.

PRODUCT LINE TEAM AREA: Training, Simulation and Modeling

SPONSOR: PMA-205; PMA-299

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Priority Number:

TITLE: Shallow Water Directional Noise Measurement Sensors

OBJECTIVE: Develop and fabricate a sensor to measure the directional noise and reverberation characteristics for active systems in shallow water ocean areas.

DESCRIPTION: Active sonar detection and classification systems require detailed knowledge of the background noise and reverberation field in order to operate effectively. Knowledge of the reverberation direction and amplitude is important in selecting sonar transmitter parameters, setting receiver beamwidths and steering angles, and establishing sonar deployment geometry. Currently, only limited background noise directionality is attainable with on-board or expendable measurement sensors. An innovative approach to measure the directional noise and reverberation field *in-situ* is sought. Emphasis should be placed on a compact, affordable automatic measurement sensor capable of being used in expendable air deployed measurement devices. It is anticipated that the sensor will require a sound source, receiving array, and processing algorithms within the device. The sensor should be capable of operating at frequencies below 1000 Hz but as a goal be capable of operating between 50 Hz and 10 kHz. The sensor must survive the shock, vibration, and temperature environments of an air deployed device, and be capable of providing both monostatic and bistatic directional measurements in water depths to 1000 ft.

Phase I: Develop a conceptual design for a directional noise measurement sensor that meets Navy needs. Include transducer elements, electronic interface circuitry, and processing algorithms that will implement the proposed concept. Also conduct a study to investigate the feasibility of integrating this sensor into an A-size sonobuoy configuration.

Phase II: Develop detailed designs for the Phase I sensor design and fabricate a limited number of prototype sensors suitable for open ocean proof of concept testing. Conduct preliminary testing in a laboratory and in ocean shallow water environments and report the results of this preliminary testing to the Government.

Phase III: The sensor, upon meeting Navy requirements, will be transitioned into the airborne sensor production program and/or into a multi-purpose environmental measurement probe program.

COMMERCIAL POTENTIAL: The directional noise sensor developed should have applicability to a variety of commercial needs including investigations of marine mammal behavior and habitat changes due to increasing noise levels in the ocean environment. This device could also be used to monitor the level and direction of underwater noise caused by offshore oil exploration/drilling or other underwater commercial activities to assure compliance with EPA regulations.

References: TAMDA (Tactical Acoustic Measurement and Decision Aid) Program, funded by CNO (N096) FY-99 to FY-01 and in CNO (N88) POM FY-02 to FY-07.

Key words: Active Sonar; Ocean Environment; Noise; Reverberation; Sensor; Expendables

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Why are we proposing this topic: With the shift in ASW operations from open ocean blue water to shallow water littoral environments the need has arisen for a better characterization of the background noise and reverberation in these acoustically harsh environments. Historical measurements in these environments are limited or non existent. Direct *in-situ* measurements of these parameters will provide a valuable tool in predicting active sonar detection and classification performance.

Total Ownership Cost Reduction: The ambient noise and reverberation background that these measurement sensors provide will reduce the cost and time to actively surveil an area by optimizing sensor placement and mode of operation.

Category: Exploratory development

Science/Technology Area: Battlespace Environment; Modeling and Simulation; Sensors; Environmental Science; Ocean Science

Navy Requirement: Supports STRG requirements 6.1.b.

PRODUCT LINE TEAM AREA: Avionics and Sensors

SPONSOR: PMA-264, PMA-299, PMA-290

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Priority Number:

TITLE: High-Bandwidth Scene Projector Drive Electronics

OBJECTIVE: Develop high-bandwidth scene projector electronics capable of providing signals to large area infrared emitter arrays (e.g., 1024x1024 pixels at rates up to 420 megabytes/sec (2 bytes per pixel)). High-bandwidth drive electronics will be incorporated into the Navy's Air Combat Effective Test and Evaluation Facility (ACETEF) for use in simulation/stimulation of integrated/installed EO/IR sensors and associated processing avionics.

DESCRIPTION: Technologies are needed to develop drive electronics to handle a throughput of approximately 420 megabytes/sec (2 bytes per pixel) to effectively evaluate current and future systems under test (SUTs). Significant innovation is required to solve the problem of data throughput. The high-bandwidth scene projector drive electronics will accommodate data processing functions at up to 420 megabytes/sec such as: (1) accept as input 16 bit pixels, (2) playback from local memory stored sequences, (3) perform 32 point linear interpolation per pixel non-uniformity correction, and (4) output scan conversion. Under this task, innovative approaches to fabricate and demonstrate high-bandwidth scene projector driver electronics will be developed. The electronics should be capable of supporting high-resolution infrared emitter arrays that perform projection at real-time rates. Cost reductions can be expected in:

-More effective stress testing of IR sensor performance capability, thereby reducing the number of rescheduled open range test flights caused by sensor system malfunctions or performance deficiencies.

- Providing pilot and operator training using wide field-of-view IR sensor simulations/stimulations that require high-bandwidth drive electronics.

- Supporting sensor developers with the ability to test engineering and managing development (EMD) sensors under dynamic and accurate simulations/stimulations.

- Providing aircrew with the ability to test the effectiveness of evasive tactics, thereby increasing safety of flight.

Phase I: Produce a design for prototype high-bandwidth scene projector drive electronics capable of controlling government identified infrared emitter arrays (either existing or emerging technology) with emphasis on throughput, weight/volume, low noise, uniformity, and adaptability to a variety of emitter array types and formats. Design trades for optimizing throughput must also be shown.

Phase II: Construct prototype high-bandwidth scene projector drive electronics and demonstrate control of several government furnished emitter arrays. Develop a graphical user interface (GUI) through which the user will have control of all functions of the drive electronics. The GUI must be hosted on either an NT or UNIX platform. Electrically interface the prototype electronics with existing Navy image simulation/stimulation equipment. Also conduct trade studies to validate the choice of drive electronics.

Phase III: Transition the high-scene projector drive electronics technology to a production capable item. Expand the applicability of the drive electronics to other sensor test programs, as well as to commercial applications.

COMMERCIAL POTENTIAL: Commercial applications include associated information systems and communications areas requiring high data throughput driver electronics.

References:

1. R.G. Lane, "Innovations in Infrared Scene Simulator Design", SPIE Proceedings, 3368, pp. 78-88, 1998.
2. R.A. Ericson, et. Al., "Unique Digital Imagery Interface Between a Silicon Graphics Computer and the Kinetic Kill Vehicle Hardware In the Loop Simulator (KHILS) Wideband Infrared Scene Projector (WISP)", SPIE Proceedings, 3368, pp. 376-381, 1998.

Key words: Infrared Projection; Stimulation; Emitters; Missile Detection and Warning; Real-Time Data; Signal Analysis; Test and Evaluation

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Why are we proposing this topic: Integrated pre-flight avionics testing of advanced aircraft requires the use of high-resolution ultraviolet/visible/infrared simulators/stimulators to assess the effectiveness of the sensor SUTs. Current drive electronics for these stimulators are designed to handle a throughput of approximately 60-100 megabytes/sec (2 bytes per pixel). Currently available emitter arrays are capable of being addressed at much higher rates. Emerging emitter array technology, coupled with future missile warning systems and multi-function sensors, will also push the bandwidth requirements much higher. Without high-bandwidth drive electronics, missile-warning systems will not be fully tested in an operationally realistic combat condition. This includes testing across a full range of engagements, human factors, countermeasure effectiveness, and effects of platform maneuvers, which stress the ability to fully evaluate these systems. Therefore, milestone decisions will be made at risk and more importantly the potential exists that the warfighter may receive a system that will not provide the required results.

Total Ownership Cost Reduction: This technology has the potential of reducing total ownership costs for aircraft sensor test and evaluation by: reducing number of flight tests, maintenance costs; predicting failures by monitoring performance; provide pilot training of warning systems, thereby reducing flight test time and increasing flight safety.

Category: Basic research, Exploratory development

Science/Technology Area: Sensors; Electronics; Manufacturing Science; Mathematics; Electronic Warfare; Manpower, Personnel, and Training Systems

Navy Requirement: Supports STRG 3.4.a, 3.3.d, 3.2.a, 3.1.c, 3.1.a

PRODUCT LINE TEAM AREA: Avionics and Sensors; Integrated Support Systems

SPONSORS: PMA-290, PMA-231, RICOM, Army, TECOM

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Priority Number:

TITLE: Novel Signal Processing Algorithms to Exploit and Classify Active Sonobuoy Returns

OBJECTIVE: Use unique non-conventional signal processing concepts to enhance performance of future airborne Active ASW systems operating in high clutter environments.

DESCRIPTION:

Phase I: Define unique and innovative active signal processing concepts and classification algorithms that will exploit the signal structure and signal returns in an active (coherent and incoherent) airborne mission. The concepts must demonstrate significant if not total elimination of clutter and false alarms while enhancing the capability to detect the true signal. The concept must be low cost, simple and transportable for ease of implementation into existing and future active processing systems. The Phase I effort will identify the algorithms to be exploited, the system architecture, the techniques employed and signal exploitation. A working demonstration of the algorithm will be required.

Phase II: Develop a redefined and fully working prototype of the algorithms and techniques defined and demonstrated under Phase I. The prototype system will demonstrate the value added and performance attributes using real data (Secret Level) furnished by the Government and *in-situ* at sea evaluation.

Phase III: Implementation of the processing concepts and techniques in fleet ASW platform avionics (P-3, S-3, SH-60).

COMMERCIAL POTENTIAL: The system concepts and signal processing techniques developed under this task can be applied to commercial oceanography topography, bottom sediment characterization, environmental analysis and commercial sonar systems. These techniques could also be beneficial for commercial security and surveillance systems.

References: None

Key words: Anti-Submarine Warfare; Active Signal Processing; Novel Classification Algorithm Techniques

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Why are we proposing this topic: To develop new techniques (not currently being developed by ONR, PMA-264, etc.) for active signal processing

Total Ownership Cost Reduction: This will reduce the manned aircraft cost by reducing the false alert pursuit of current and future systems.

Category: Exploratory development

Science/Technology Area: Sensors

Navy Requirement: STRG (H 2.1.b, H 1.5.b, H 6.1.a, M 6.2.g)

Product Line Team Area: Avionics and Sensors

SPONSOR: PMA-264, PMA-290

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Priority Number:

TITLE: Small GPS Controlled Reception Pattern Antenna for Aircraft

OBJECTIVE: Develop and demonstrate a small controlled reception pattern antenna (CRPA) for naval aircraft applications that provides cost-effective anti-jam capabilities.

DESCRIPTION: The U.S. Navy and Marine Corps employ GPS navigation and targeting subsystems in a major fraction of current airborne weapon systems. Dependence on GPS continues to increase, making reliable and accurate GPS operation a critical requirement for successful mission accomplishment by current and future weapon systems. Battle situations are expected to present harsh environments for GPS operation, with high levels of radio frequency (RF) interference from spoofers, jammers, and other electronic warfare equipment, resulting in degraded GPS accuracy or complete loss of GPS operation. Spatial nulling by CRPA systems is very effective at countering these RF threats, and is the only reliable method for overcoming some types of threats. Conventional CRPA systems are large and expensive, and include antennas which are large, non-conformal, have high radar cross-sections (RCS), and otherwise unsuitable for current and future airborne platforms. Therefore, a need exists for a new GPS antenna system. The system should provide anti-jam capability against expected threats at an affordable price. It should be small enough for conformal installation aboard small airborne vehicles. Key technical challenges for this new antenna system include a) radiation pattern control with a small aperture area, b) electrically small broadband antenna elements, c) small and efficient nulling electronics and algorithm, and d) RCS control.

Phase I: Conduct a trade study of electrically small arrays for aperture size versus pattern agility versus implementation approach. Establish a preliminary system architecture, array configuration, and radiating element design(s). Generate measured and/or computational data of key system elements.

Phase II: Design, fabricate, and demonstrate a proof-of-concept antenna system, including radiating elements, radome, and nulling electronics.

Phase III: Transition this antenna technology for airborne integration, operation evaluation, and production, provided sponsorship is secured from F-18, JSF, F-14, EA-6, P-3, V-22 or other aircraft programs

COMMERCIAL POTENTIAL: This program is focused on providing the military with protection against intentional threats. Commercial users are faced with unintentional RF interference from television and radio broadcasts, PCS systems, Satcom systems, and other communication systems. Commercial GPS users also suffer performance degradation due to GPS signal multi path. The proposed new antenna will solve both of these civilian problems.

References: None

Key words: Antenna; GPS; Controlled Reception Pattern Antenna; Anti-Jam; Airborne

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Why are we proposing this topic: According to the National Research Council's Committee on the Future of the Global Positioning System, "The anti-jamming and anti-spoofing capabilities of military GPS user equipment are critical to successful mission completion in a battlefield environment characterized by both U.S. and enemy spoofers and jammers." "Therefore", the report concludes, "GPS-based navigation systems used on aircraft, ships, land vehicles and precision-guided munitions must ... be able to null out the jamming signal..." The report recommends that, "Nulling antennas and antenna electronics should be employed whenever feasible and cost effective." It also recommends that, "Research and development focused on reducing the size and cost of this hardware should actively be supported." It is very clearly stated in these reports that, "These future developments aimed at reducing the size and cost of antenna structures should be actively pursued."

The problem is that the U.S. Navy primarily employs fixed reception pattern antennas (FRPAs), which do not offer spatial nulling capability. The deficiency is that there is not available a suitable replacement for these FRPA antennas that will offer spatial nulling in a comparable package size and at an affordable price. The consequence is high susceptibility to simple jammer threats existing and being developed today. The critical challenge to be overcome by this project is the realization of a miniature GPS antenna system that offers at least 20 dB J/S, without significant penalties in positional accuracy measurement or in functional availability.

Total Ownership Cost Reduction: This antenna system would reduce total ownership costs by its size, weight and cost of development, and integration.

Category: Exploratory development

Science/Technology Area: Electronics; Mathematics; Physics; Antennas; Electronic Warfare; Modeling and Simulation; Sensors

Navy Requirement: Supports STRG 1.6.a, 2.1.g, 2.1.j, 3.2.a, 3.2.f

PRODUCT LINE TEAM AREA: Avionics and Sensors

SPONSOR: PMA-290

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Priority Number:

TITLE: Expendable Broadband Projectors for Undersea Warfare

OBJECTIVE: Develop innovative hardware for producing a broadband acoustic projector that will enable anti-submarine warfare (ASW) and mine warfare (MIW) sonar systems to adapt to harsh shallow water environments.

DESCRIPTION: Active sonar systems are very much affected by the environment within which they operate. This is particularly true in shallow water, where boundary interactions tend to defocus and lessen the strength of the source and echoes. Additionally, local bathymetric features along the path of the signals can obscure the signal or cause false returns, emulating real targets. Furthermore, surface, bottom, and volume reverberations add to the background noise level and reduce signal-to-noise level dramatically. Sonar systems that have the ability to change their operating parameters to adapt to the environmental characteristics will give better performance than less capable fixed parameter systems. These parameters include source level, beam pattern, frequency and waveform shape. A design concept should be developed based on innovative projector implementations, resulting in a transducer with high power, wide band frequency coverage and complex signal waveform capability. The overall objective is to develop an innovative transducer that is adaptable over a number of parameters, has high reliability, and is low in cost. Various transducer designs should be evaluated using appropriate mathematical models A single design will be selected for in-depth evaluation.

Phase I: Develop a detailed design for an innovative acoustic projector, including assembly drawings, modeling of predicted performance, and cost estimates. Analyze the performance based on simulated data such as that produced by state-of-the-art models.

Phase II: Build a prototype acoustic projector of the design developed in Phase I, demonstrating its innovative features. Test the transducer at a test facility designated by the Navy. Investigate selected waveforms using recorded sea data for regions of known propagation conditions and for their ability to mitigate the problems that can be associated with shallow water sonar. Conduct sea tests of the broadband acoustic projector. Identify candidate Navy systems for transition of these techniques developed under this effort.

Phase III: Build an improved prototype acoustic projector aimed at a specific Navy tactical application, showing advantages in cost or performance over the existing technology used or being considered for that application. Transition technology to an ongoing Navy acquisition program.

COMMERCIAL POTENTIAL: The technology developed should have applicability to a variety of commercial needs. Commercial potential is dependent on specific problems addressed but include off-shore petroleum and mineral exploration; ocean bottom mapping; underwater obstacle avoidance; underwater inspection services including environmental assessment; non-destructive evaluation of structures, and medical imaging technology; and enhanced underwater acoustic communications, for example among divers.

References: None

Key words: Active Sonar; Transduction; Sensor; Expendables

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Why are we proposing this topic: Shallow littoral waters present a challenge to the sonar designer developing a system that will perform optimally under all the unique conditions encountered in these environments. A broadband projector will provide the system with flexibility and allow adaptation to the acoustic environment. This will provide maximum performance over single frequency systems when operating in these highly variable acoustic environments

Total Ownership Cost Reduction: A sonar system that is adaptable to the acoustic conditions on site will outperform conventional fixed frequency systems. Ultimately it will also reduce the need and cost for multiple sensor systems or the number of sensors required to complete the mission, and the on station time for maritime patrol aircraft (MPA).

Category: Exploratory development

Science/Technology Area: Sensors

Navy Requirement: STRG requirement 6.2.a.

PRODUCT LINE TEAM AREA: Avionics and Sensors

SPONSOR: PMA-264; PMA-299

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Priority Number:

TITLE: Compact Mid-Infrared Laser for IRCM

OBJECTIVE: Demonstrate the feasibility of developing a low-cost, small, lightweight mid-IR laser as a source for directed IR countermeasures (DIRCM) on board tactical aircraft.

DESCRIPTION: The most advanced threat to tactical aircraft is the IR missile threat. These IR missiles have accounted for more than 80% of all of the aircraft combat losses. The advanced IR threat may only be countered in the end game with a limited number of expendable IR decoys. Off-board countermeasures require multiple IR decoys deployed in the proper combinations, for a specific threat, at precisely the correct time. Improvements to existing threats and emerging advanced threats may render existing countermeasure techniques ineffective. An airborne DIRCM solution is needed to augment existing IR expendable decoys.

The Navy seeks innovative advanced technology developments in the generation and propagation of directed laser energy. Tactical aircraft DIRCM systems require a compact, high-power laser source in the mid-IR band. Current IRCM lasers are costly and exceed weight, space and power constraints of Navy tactical aircraft. Promising laser technologies that may provide a low-cost, compact solution for tactical aircraft DIRCM systems will be assessed for feasibility, prototyped, integrated into an existing system and demonstrated for suitability. The selected laser technology must efficiently generate sufficient power to effectively jam IR missile seekers at distances large enough to prevent damage to the aircraft.

Phase I: Research appropriate technologies; conduct atmospheric propagation analyses to define optimum lasing wavelengths; establish innovative concepts/approaches; perform tradeoff analyses; and define hardware, software, safety, and integration requirements. Prepare validation test plan and document results.

Phase II: Prototype a DIRCM laser transmitter and perform the requisite analyses to integrate it with an existing CM system. The integrated laser will be tested in the laboratory and ground tested (long-range) to demonstrate acceptable performance. Deliverables will include the prototype laser, system interface control document (ICD), test plan, test report and a technical report documenting the performance parameters of the delivered laser.

Phase III: Upon successful completion of the Phase II effort, the DIRCM system will transition to PMA-272 for use in defensive systems being developed for tactical fixed- and rotary-wing aircraft.

COMMERCIAL POTENTIAL: The successful mid-IR countermeasure solution can be commercialized to provide the tactical fleet with a low-cost, highly effective IRCM solution. These systems may be adapted to commercial aircraft to counter the growing terrorist threat to commercial aviation. Small, lightweight, high-power laser mid-IR sources also have a large number of commercial applications such as range finders. Portable, small, lightweight, low-cost equipment lasers also are of interest to the medical community for remote applications such as clinics.

References: None

Key words: Infrared; Infrared Countermeasures; Laser; Integration; Tactical Aircraft; Jammer; Directed IR Countermeasures

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Why are we proposing this topic: There is a need for small, high-power lasers for use on Navy tactical aircraft countermeasure systems. Current laser configurations lead to a high-risk platform integration issue utilizing the current optical tubing and weight factor. Without a small high-powered laser, the implementation of IRCM on the F-18, V-22, and AV-8 is a technical risk effort, which will significantly increase total life-cycle cost and reduce TACAIR DIRCM system reliability. The higher power laser will effectively jam advanced threats at distances required to ensure aircraft survivability for most platforms including large Air Force transports.

Total Ownership Cost Reduction: TACAIR DIRCM will be deployed in all of the F-18 E/F aircraft with an expensive laser source. There is a need to reduce the cost, size, and weight of the laser jammer so that the system is more affordable. The compact laser proposed in this SBIR would reduce the cost of procurement, increase reliability equating to a lower life-cycle cost, and lower the life-cycle cost.

Category: Advanced development

Science/Technology Area: Electronic Warfare

Navy Requirement: STRG 3.2.a.2: Improve aircraft survivability against IR and EO threats

PRODUCT LINE TEAM AREA: Avionics and Sensors

SPONSOR: PMA-272

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Priority Number:

TITLE: EO/IR Sensor Applications on Supersonic Vehicles

OBJECTIVE: Develop techniques, which permit EO/IR sensors to operate in the high temperature environment of supersonic weapons and aircraft.

DESCRIPTION: Time-on-target requirements for land-attack weapons and aircraft have established the need for faster en-route and terminal velocities, often supersonic. EO/IR sensors, which perform target acquisition and track functions for the vehicles, are required to operate in very high temperature environments. The sensor dome or window, which isolates the sensor's internal optical system from the outside environment, must withstand the high temperatures while, at the same time, transmitting the optical radiation required by the sensor to perform acquisition and track.

The purpose of this SBIR is to examine techniques, which might permit EO/IR sensors to effectively operate in high temperature environments of supersonic flight. Possible approaches include conductive or convective heat sinking, heat absorption by bi-state materials, coolant air on the window, closed or open cycle cooling, heat shields, etc. Geometrically position the sensor to a lower temperature location on the flight vehicle is permitted as long as it retains a field of view in the forward direction.

In order to bound the technological requirements, respondees may consider supersonic flight up to Mach 4 at altitudes up to 60,000 feet. Sensor operating time at lower altitudes can be limited to two minutes at Mach 2 following a six-minute flight at Mach 4 at 60,000 feet. Cost will be an important consideration in any proposed solution.

Currently available EO/IR sensors are limited in their application to supersonic flight conditions due to unacceptable deterioration of sensitivity or resolution or both. Infrared window and lens materials lose transmission capability or generate a high background flux, which greatly reduces system sensitivity.

Respondees should not address the problem of EO/IR wavefront distortion due to the supersonic shock wave since that problem is being addressed elsewhere. Increased temperatures due to the shock waves, however, should be addressed. Proposed solutions should discuss the selection of window and lens materials, electronic components, gimbals, and detector arrays. Proposed sensors may operate in the visible or infrared regions and may include active or passive sensors.

Phase I: Investigate various approaches that will allow EO/IR sensors to effectively operate in high temperature environments of supersonic flight. Demonstrate, through modeling analysis, the most promising approaches. The results of the Phase I effort should clearly demonstrate not only the feasibility, but establish a defined approach for a phase II effort.

Phase II: Develop, test, and demonstrate under realistic conditions the most promising sensor approaches. Tests will demonstrate the capability of critical items such as windows and lenses to operate effectively in the high temperature environments. During Phase II, commercial and military sponsors for Phase III will be sought.

Phase III: Build prototype sensors using the techniques and components demonstrated in Phase II. Apply to military and commercial sensors used in supersonic flight.

COMMERCIAL POTENTIAL: The technology developed in the SBIR will have a wide variety of commercial applications. Examples are supersonic aircraft which will employ passive or ladar sensors to perform safety area searches; re-entry vehicles which will use infrared or visible sensors for navigation or guidance after entering the earth's atmosphere; space vehicles which operate in planetary atmospheres such as Venus or Jupiter. Cooling techniques such as heat sinks have multiple private sector applications.

References: References will be provided to DTIC for distribution to requesting bidders.

Key words: Sensors, Supersonic, High Temperature, Bi-State, Infrared Materials

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Why are we proposing this topic: This effort will provide the Navy and other military services with significantly improved capabilities to carry out high-speed military operations. All three Services will benefit. The higher speeds will allow better time-on-time target capabilities. They will also provide more kinetic energy to the weapons, which will result in greater penetration by warheads.

Total Ownership Cost Reduction: If the target can be detected earlier and at a higher probability, there will be a reduction in the number of missiles required to ensure a kill. Impacts to total ownership costs are expected to be minimal.

Category: Exploratory development

Science/Technology Area: Sensors; Materials

Navy Requirement: Supports STRG 3.1.c.

PRODUCT LINE TEAM AREA: Avionics and Sensors; Weapons

SPONSOR: PMA-258, PMA-242

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Priority Number:

TITLE: GPS Ground Plane Nulling Antenna

OBJECTIVE: Develop a low-cost GPS antenna that is effective against ground-based jammers.

DESCRIPTION: The development of the GPS navigation system has generated a myriad of users including weapons, aircraft, and ships. The effectiveness of this navigation system has prompted adversaries to exploit the vulnerabilities of the GPS navigation system by the use of ground and airborne GPS jammers. Tactical weapons are expected to be subjected to low power and moderate power jammers that are located on the ground. This SBIR will address how to counter ground-based jammers without resorting to the cost, weight, or power penalties typically associated with Controlled Reception Pattern Antennas (CRPA). The low-cost antenna is expected to provide nulling of GPS jammers on the ground and reception of GPS satellite signals.

Phase I: Define innovative antenna design concept(s) that provide a minimum of 20 dB attenuation of signals (objective 30 dB) that are less than 5 degrees above the antenna horizon. The antenna should also provide a 0 dB or greater gain more than 20 degrees above the antenna horizon. The antenna should have a design to cost goal less than $1,000, require no electronic processing or electrical power, possess stealth characteristics, and have a twenty-year shelf life. The antenna is mounted on the top of the weapon conformal to a flat surface. The new antenna design will replace an existing antenna with a three-inch aperture. More specific form factor requirements will be provided by the Government during this phase. Phase I should demonstrate the feasibility of the design through analysis or breadboard hardware. Initiate the design of a prototype antenna that can be fabricated and tested during phase II.

Phase II: Finalize the design, fabricate, and test the selected antenna concept evolving from the phase I program. The testing should include both RF gain pattern characterization and survivability characterization. Initiate producibility studies of the design along with production planning and design to cost analysis. Fixtures to support the testing may be provided by the Government.

Phase III: Build 10 ship sets that will be used by the government for flight test, environmental qualification, and reliability development/ growth testing. Provide engineering support via corrective action redesign resulting from the above testing.

COMMERCIAL POTENTIAL: This antenna concept is applicable for any commercial application of GPS which is subjected to electromagnetic interference such as business aircraft or helicopters flying in and out of populated areas. It would be particularly useful for commercial aircraft, which might be subjected to potential terrorist threats employing low power GPS jammers around airports. The commercial market could drive the cost of the antenna below the desired $1,000 cost objective.

References: None

Key words: GPS; Antenna; Countermeasures; Weapon; Precision Attack

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Why are we proposing this topic: The primary purpose of this SBIR is to reduce the cost of GPS counter countermeasures, as mandated by the JSOW Joint ORD. The success of GPS aided weapons has been so well publicized that future conflicts are expected to include countermeasures jamming by the enemy to counter that high degree of effectiveness. The classical method of GPS counter countermeasures is the CRPA. This approach has a high theoretical potential but is still immature as a technology, very expensive, and requires unacceptable form factors for a weapon. The ground plane nuller approach is effective for low-cost weapons and should be affordable today.

Total Ownership Cost Reduction: The life-cycle cost reduction of this ground base nuller is expected to be $1.4 Million over the Fixed Reception Pattern Antenna (FRPA) that is on existing weapons. Details of the life-cycle cost (LCC) should be available with the above mentioned producibility study.

Category: Advanced development

Science/Technology Area: Electronics; Mathematics; Physics; Electronic Warfare; Sensors

Navy Requirement: Supports STRG 3.1.c, 3.2.c

PRODUCT LINE TEAM AREAS: Avionics and Sensors; Weapons

SPONSOR: PMA-201

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Priority Number:

TITLE: Low-Cost GPS Oscillator

OBJECTIVE: Develop a low-cost GPS oscillator that meets military GPS accuracy requirements.

DESCRIPTION: The development of the GPS navigation system has generated a myriad of users including weapons, aircraft, and ships. The GPS receivers, referred to as the user equipment, use a high quality crystal oscillator to receive and properly interpret the GPS signals from the GPS satellites. This SBIR will address the development of a temperature compensated or other low power oscillator that provides the same quality performance as today's oven controlled crystal oscillators without the size, weight, power, and cost penalties of the oven controlled oscillator.

Phase I: Develop a crystal oscillator design concept and perform analyses to verify that the design will meet the following characteristics. The oscillator will cost less than $200 (goal less than $100), use less than two watts of power, support fast response over the standard military temperature range (rated stability within 30 seconds - goal of 3 seconds), and provide good long term stability (1 ppm over 20 yrs) and good short term stability (< 5 x 10 e -10 rt Allan variance, t = 0.1 sec - goal of < 3 x 10E-11 rt Allan variance, t = 1.0 sec). Initiate the design of an engineering prototype oscillator than can be fabricated and tested during Phase II.

Phase II: Finalize the design. Fabricate, and test the selected crystal oscillator concept evolving from the Phase I program. The testing of the engineering prototype should include testing over the entire environment range. Initiate producibility studies of the design along with production planning and design-to-cost analysis. Provide three test articles to the Government for early engineering assessment.

Phase III: Build 10 production representative units that will be used by the Government for flight test, environmental qualification, and reliability development/growth testing. Provide engineering support via corrective action redesign resulting from the above testing.

COMMERCIAL POTENTIAL: This oscillator design is applicable for any commercial application of GPS which desires low power utilization combined with rapid response. This oscillator would improve GPS performance where the receiver is subjected to electromagnetic interference such as business aircraft or helicopters flying in and out of populated areas.

References: None

Key words: GPS; GPS Receiver; Crystal Oscillator

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Why are we proposing this topic: The primary purpose of this SBIR is to reduce the cost of military GPS receivers. Military utilization of GPS requires a high quality crystal oscillator to support quick response, direct Y-code acquisition, improved A/J characteristics, and improved State 3 performance. This performance can be obtained by use of a oven controlled crystal oscillator, but that approach is expensive both due to the cost of the oscillator and the overhead costs associated with the integration. The low power crystal oscillator will maintain all of the advantages of the more expensive oven controlled oscillator but cost less and eliminate the overhead integration costs.

Total Ownership Cost Reduction: The cost of ownership of the new oscillator is expected to be less than the cost of any oscillator used today with the same performance characteristics. Details of the LCC should be available with the Phase II design to cost study addressed above.

Category: Advanced Development

Science/Technology Area: Electronics; Mathematics; Physics; Electronic Warfare; Sensors

Navy Requirement: Supports STRG 3.2.c

PRODUCT LINE TEAM AREAS: Avionics and Sensors; Weapons

SPONSOR: PMA-201, PMA-290

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Priority Number:

TITLE: Real-Time Pattern Recognition Algorithms for High Density Commercial and Military Applications

OBJECTIVE: Develop algorithms that can perform real-time pattern recognition in applications involving simultaneous inspection of very large numbers of images with minimum processor memory and throughput.

DESCRIPTION: The Standoff Land Attack Missile Expanded Response (SLAM-ER) is the U.S Navy's air-to-ground Standoff Outside Area Defense (SOAD) cruise missile used to interdict stationary and re-locatable enemy targets at ranges in excess of 150 NM. The SLAM-ER Operational Requirements Document (ORD) has an established objective that the SLAM-ER provide "autonomous acquisition and recognition of the target by the missile after launch." Automatic Target Acquisition (ATA) currently embedded in a missile uses a general pattern matching algorithm approach to compare, correlate and attack pre-planned target locations within a scene as viewed by the weapon infrared seeker. The limitations of this approach are threefold. First, the missile can only recognize and attack a pre-planned location within a scene; if the target moves after the mission is planned, the missile will not recognize this change and will attack the target's previous position if the pilot does not intervene. Second, the missile's mission planned terminal axis of advance is constrained to stay within specified limits of the target image-viewing axis. Finally, this approach carries with it large memory and processing requirements for target imagery data files (a maximum of three target images can be loaded). The results of this SBIR will be applied to incorporating true Automatic Target Recognition (ATR) into SLAM-ER with the goal of achieving this performance with reduced hardware processing requirements. The software application's performance will come from downloading multiple images of target of interests (different aspects, different times of day) and comparing these with seeker video frame data and performing processing to recognize and track the target to impact with no pilot intervention required.

Phase I: Identify and analyze algorithms that show the most promise of being able to perform pattern matching in real time, of hundreds or thousands of digitized records. Select the most promising algorithm.

Phase II: Develop, test, and demonstrate under realistic conditions the most promising real-time autonomous pattern recognition algorithms.

Phase III: Build prototype real-time autonomous pattern recognition systems by the techniques demonstrated in Phase II. Apply to military seekers and forward looking infrared (FLIR) systems as well as to commercial imaging and print recognition systems.

COMMERCIAL POTENTIAL: Increasing numbers of military and commercial systems are faced with the task of automatically performing pattern recognition examinations of a large number of digital files. The digitized data can contain fingerprint records, digitized photographs, DNA records, eye records or any number of other records that must be examined in order to find a match to a reference file. An important example is to find a commercial or military object of interest, such as a military target immersed in a cluttered background that is infinitely variable. Current autonomous recognition capabilities are limited because of the immense memory and processing throughput requirements associated with real-time correlation of large numbers of digitized data files. Several techniques have evolved to alleviate the memory and throughput limitations. These include data compression; use of mathematical techniques such as Fourier transforms to process in complex space; use of templates such as edge templates, corner templates or other geometric templates; polarization techniques; and fuzzy algorithms associated with neural networks. The purpose of this SBIR is to identify those algorithms that that show the most promise of being able to perform pattern matching in real time for hundreds or thousands of digitized records. The new algorithms will have a wide variety of applications such as identifying individuals at airport security checks, military seeker autonomous target recognition systems, and DNA pattern correlation.

References:

Key words: Pattern Recognition; Correlation,; Algorithms; Autonomous Target Recognition

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Why are we proposing this topic: This effort has the potential to provide the Navy and other military services with significantly improved optical/infrared autonomous target recognition capabilities. All current systems suffer from limited real-time Autonomous Target Recognition (ATR) capability due to the memory and throughput restrictions of their ATR algorithms. The innovative algorithms demonstrated in the SBIR will result in greater flexibility of autonomous weapons as well as an aid to man-in-the-loop systems when targets are immersed in a variety of cluttered background scenes.

Total Ownership Cost Reduction: This SBIR, if successful, will result in the development of more efficient and faster processing algorithms that will in turn, reduce hardware processing requirements. Reduced hardware processing requirements will result in the reduction or elimination of the need for specialized or proprietary processing hardware systems and allow COTS processors to be used, thus reducing TOC. Additionally, these algorithms can be shared across the military services, thus reducing overall cost to DOD for development of ATR software.

Category: Exploratory development

Science/Technology Area: Computers, Software; Sensors

Navy Requirement: 3.1.c, Improve targeting sensor performance

PRODUCT LINE TEAM AREA: Aircraft; Weapons; Avionics and Sensors

SPONSOR: PMA-258

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Priority Number:

TITLE: Geometric Patterning of Radar Absorptive and Reflective Materials (RARM) and Selective Combining of RARM materials to Achieve Improved Electromagnetic Interference (EMI) Protection and Significantly Reduced Radar Cross Sections (RCS).

OBJECTIVE: Investigate various shapes and patterns of RARM materials to ascertain which geometric patterns result in improved EMI protection and reduced RCS. Investigate which combinations of RARM coatings give improved EMI protection and reduced RCS. The end result of this demonstration will be an EMI-reduction/radar cross section technology that provides equal or better protection to military and commercial aircraft, land craft, and sea craft.

DESCRIPTION: Commercial and military vehicles are faced with the need to operate properly in high EMI fields. They are also often at risk if their RCS permits easy detection by opposing radar systems. Military systems include missiles, aircraft, ships, and ground vehicles. Commercial vehicles include coastal security craft, space vehicles, and aircraft that operate near high-power radar. Current RARM coatings are costly and heavy. They often do not give significant protection over large angles and are limited in frequency range. Their performance is often limited by the shape and size of the vehicle that they cover.

It has been shown that properly shaped RARM coatings can provide more protection than uniform coatings. Shaped coatings can reduce the EMI/RCS in areas where it is the hardest to achieve results such as broad side. Shaping the RARM can provide equal or better protection while using significantly less material. The result is less cost and weight. The use of properly applied RARM results in larger production buys and increased vehicle mileage due to reduced weight and volume.

Current investigations of EMI/RARM materials are concentrated in the area of investigating the materials themselves. Few demonstrations of the improvements achievable from geometric shaping have been conducted. Fewer still are documented. Although much progress has been reported in the development of materials, little progress has been reported in the area of combining those materials to provide protection to various areas of the base vehicle.

Phase I: Identify the most promising methods of geometric patterning and RARM materials to improve EMI protection and reduce RCS.

Phase II: Develop, test, and demonstrate under realistic conditions, the most promising shapes and combinations of RARM to provide additional protection over current methods of applying RARM.

Phase III: Build and test prototype RARM-protected bodies using the techniques demonstrated in Phase II. Apply to military systems as well as to the most promising commercial systems.

COMMERCIAL POTENTIAL: The new algorithms will have a wide variety of commercial applications. Many commercial systems have to operate in the vicinity of high-power radar. EMI protection will be provided by the technologies developed under this SBIR. Some commercial vehicles seek lowered RCS for security reasons. The technology provided in this SBIR will help provide the required protection at a lower cost and weight.

References: References will be provided to DTIC for distribution to requesting bidders.

Key words: Radar; Radar Cross Section; Electromagnetic Interference; Radar Absorbing Materials

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Why are we proposing this topic: This effort will provide the Navy and other military services with significantly improved capabilities to operate in high-power EMI fields. Their ability to remain undetected by opposing radar systems will also be improved and the improvements will be accompanied by lower costs. All three services will be beneficiaries of the RARM demonstrations.

Total Ownership Cost Reduction: Current RARM coatings are costly and heavy. One of the goals of this topic is to provide lower cost coatings.

Category: Exploratory Development

Science/Technology Area: Materials, Processes, and Structures

Navy Requirement: 3.2.e, Develop new materials that increase strength and reduce weight

PRODUCT LINE TEAM AREA: Aircraft, Weapons

SPONSOR: PMA-258

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